Claims

1. An electrode comprising an oxidative drug-metabolising enzyme (DME) immobilised at the surface of the electrode to allow efficient transfer of electrons from the electrode to a catalytic site within the DME.

2. An electrode according to claim 1, wherein the DME is immobilised to the surface of the electrode by means of a linker.

3. An electrode according to claim 1 or 2, wherein the DME is covalently immobilised to the surface of the electrode.

4. An electrode according to claim 1 or 2, wherein the DME is non-covalently immobilised to the surface of the electrode.

5. An electrode according to any preceding claim, wherein the surface of the electrode is modified by the covalent or non covalent addition of chemical groups.

6. An electrode according to claim 5, wherein the electrode is a gold electrode and the chemical groups are organothiloate compounds.

7. An electrode according to claim 1, 2 or 4, wherein the electrode surface is coated with a mechanically and chemically stable polymer gel with high ionic conductivity, and the DME is trapped within the polymer gel matrix.

8. An electrode according to claim 7, wherein the polymer gel comprises polymers with a high proportion of carboxylic acid groups if the DME has many positively-charged surface residues.

9. An electrode according to claim 7, wherein the polymer gel comprises polymers with a high proportion of amine groups if the DME has many negative charges at the surface.

10. An electrode according to claim 7, wherein the polymer gel comprises polymers with a high proportion of aliphatic groups if the DME has largely hydrophobic surfaces.

11. An electrode according to claim 1, 2, or 4, wherein the DME is a CYP which is anchored at the surface of the electrode by means of a lipid membrane.

12. An electrode according to claim 11, wherein the membrane comprises long-chain fatty acids, lipids, or similar molecules, deposited on the surface of the electrode.

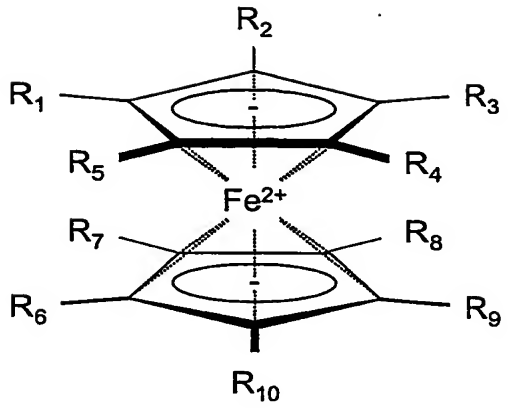
13. An electrode according to claim 2, wherein the linker comprises a delocalised electron system.

14. An electrode according to claim 2 to 4, or 13, wherein the linker comprises a hydroxyl group, an amide, an amine, a carboxylic acid group, an aromatic group, a cyclic group, a heterocyclic group such as a thiophene, or a nitrogen-containing heterocyclic group such as a pyridine, a purine, or a pyrimidine, an enol, an ether, a ketone, an aldehyde, a thiol, a thioether, a halo-, nitro-, phospho-, or sulphate group.

15. An electrode according to claim 2 to 4, 13, or 14, wherein the linker comprises a metallocene, a flavin, a quinone, or NADH.

16. An electrode according to claim 15, wherein the linker comprises a ferrocene.

17. An electrode according to claim 15, wherein the ferrocene is a compound of the following formula:



wherein:

R1 is any of the following groups: a thiol, a thioether, an amide, an amine, a carboxylic acid, a heterocyclic group such as a thiophene, or a nitrogen containing heterocyclic group such as a pyridine, a purine, or a pyrimidine; and

$R_{2\text{-}10}$ are independently any of the following: a hydroxyl group, an amide, an amine, a carboxylic acid group, an aromatic group, a cyclic group, a heterocyclic group such as a thiophene, or a nitrogen-containing heterocyclic group such as a pyridine, a purine, or a pyrimidine, an enol, an ether, a ketone, an aldehyde, a thiol, a thioether, a halo-, nitro-, phospho-, or sulphate group.

18. An electrode having a surface modified by the covalent or non covalent addition of chemical groups to allow efficient transfer of electrons from the electrode to a catalytic site within a solubilised DME.

19. An electrode according to claim 18, wherein the electrode is a gold electrode and the chemical groups are organothiloate compounds having an SH group which forms a strong bond to the surface of the electrode, and suitable functional groups for interacting with the solubilised DME.

20. An electrode according to claim 18, wherein the chemical groups comprise a delocalised electron system.

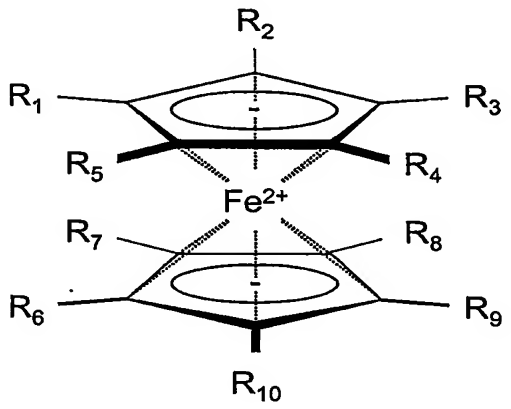
21. An electrode according to claim 18 or 20, wherein the chemical groups comprise a hydroxyl group, an amide, an amine, a carboxylic acid group, an aromatic group, a cyclic group, a heterocyclic group such as a thiophene, or a nitrogen-

containing heterocyclic group such as a pyridine, a purine, or a pyrimidine, an enol, an ether, a ketone, an aldehyde, a thiol, a thioether, a halo-, nitro-, phospho-, or sulphate group.

22. An electrode according to claim 18, 20, or 21, wherein the chemical groups comprise a metallocene, a flavin, a quinone, or NADH.

23. An electrode according to claim 22, wherein the chemical groups comprise a ferrocene.

24. An electrode according to claim 23, wherein the ferrocene is a compound of the following formula:



wherein:

R1 is any of the following groups: a thiol, a thioether, an amide, an amine, a carboxylic acid, a heterocyclic group such as a thiophene, or a nitrogen containing heterocyclic group such as a pyridine, a purine, or a pyrimidine; and

$R_{2\text{-}10}$ are independently any of the following: a hydroxyl group, an amide, an amine, a carboxylic acid group, an aromatic group, a cyclic group, a heterocyclic group such as a thiophene, or a nitrogen-containing heterocyclic group such as a pyridine, a purine, or a pyrimidine, an enol, an ether, a ketone, an aldehyde, a thiol, a thioether, a halo-, nitro-, phospho-, or sulphate group.

25. An electrochemical reaction chamber comprising a first electrode according to any of claims 1 to 17, and a second electrode.

26. A device comprising a plurality of electrochemical reaction chambers according to claim 25, wherein the first electrode of each electrochemical reaction chamber comprises a different DME.

27. An electrochemical reaction chamber comprising a first electrode according to any of claims 18 to 24, a second electrode, and a DME.

28. A device comprising a plurality of electrochemical reaction chambers according to claim 27, wherein the first electrode of each electrochemical reaction chamber comprises a different DME.

29. Use of an electrode, an electrochemical reaction chamber, or a device according to any preceding claim for electrochemical sensing.

30. Use according to claim 29, for predicting drug metabolism.

31. Use according to claim 30 in an assay which comprises the following steps:
i) providing an electrochemical reaction chamber comprising an electrode according to any of claims 1 to 17, and a candidate drug in solution;
ii) applying changing voltage to the electrochemical reaction chamber;
iii) measuring current flowing through the electrochemical reaction chamber; and
iv) determining from the measured current whether the candidate drug is metabolised by the DME.

32. Use according to claim 30 in an assay which comprises the following steps:
i) providing an electrochemical reaction chamber comprising an electrode according to any of claims 18 to 24, a DME and a candidate drug in solution;
ii) applying changing voltage to the electrochemical reaction chamber;
iii) measuring current flowing through the electrochemical reaction chamber; and
iv) determining from the measured current whether the candidate drug is metabolised by the DME.